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Green Roof Assessment by GIS and Google Earth

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Abstract

Green roofs have been more common in central Europe and are now being constructed on buildings around the world. As powerful mapping software, Google Earth can provide satellite photos of three-dimensional building roofs in big cities to GIS system. An application system integration with basic function of the environmental effect assessment and energy saving on green roof was designed by the technology of GIS and Google Earth. It is hoped that this designed application system can offer certain reference value for green roof management in urban area. This application system of green roofs assessment has been conducted to estimate the environment efficiency and energy saving compared to none green roof area in city. The green roof with useful environment efficiency including stormwater management, energy conservation, urban heat island effects mitigation, noise and air pollution reduce, urban biodiversity increase and more aesthetically pleasing environment, can be effectively assessed by designed application system. It is very evident that this application system with GIS and Google Earth technology can play an important role to manage and improve the green roof function.

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Keywords: Green Roof, Graphic Information System, Google Earth, Application Assessment.

1. Introduction

The narrative of the twenty-first century is still dominated by three key trends: population growth, economic growth and urbanisation. In regards to urbanisation, it is estimated that over 50percent of the world's population now reside in urban areas. One effect of urbanization is an increase of the area of impermeable surfaces. This in turn has numerous consequences for some city infrastructure and surrounding environment. Regarding stormwater the infiltration decreases and, in effect the surface runoff and the stress on existing stormwater infrastructure increases. Additionally studies indicate that in certain areas global warming may cause increased frequency of intense precipitation events which will also lead to increased urban flooding. Furthermore, new developments are often made at the expense of green areas.

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Fewer green areas in turn cause a decrease in canopy interception and transpiration within the city leading to increased temperature and decreased air humidity.

the widespread implementation of green roofs might have the potential to address multiple urban environmental issues by integrating the natural cooling, air filtering, and water retention properties of

vegetation in city buildings[1-10].

Although the green roofs have rich environmental function, the computer application system of green roofs in urban areas is still scarcity. In recent years, the GIS technology has been used as tool to research the roofs of buildings, but less green roof has been reported. The "virtual globe" computer application Google Earth (GE) released in 2005 is now widely used by the general public and researchers. As powerful 3-D mapping software, Google Earth can provide satellite photos of three-dimensional building roofs in different cities [11-12].

The research object in this study are to: (1) to designed the computer application system of green roofs by GIS and Google Earth; (2) to apply this designed application system to assess the different environmental function on extensive green roofs in DuJiangyan City of China.

2. Methodology

2.1 Background

Commonly construction of green roofs involves four layers: drainage material, filter preventing the loss of soil particles, soil substrate and vegetation. The thickness of the layer material and composition and the type of vegetation show great variation between different producers/designers. Requirements on the roof underlying the vegetated construction include waterproofing and protection against root penetration.

Green roofs are typically divided into two main engineering categories: intensive and extensive. Intensive green roofs are established with deep soil layers; they can support larger plants and bushes and typically require maintenance in the form of weeding, fertilizing, and watering. Extensive vegetated roofs are established with thin soil layers. They are planted with smaller plants which in the final stage are expected to provide full coverage of the vegetated roof. Extensive vegetated roofs are most commonly aimed to be maintenance free, but some fertilization is often recommended for the commercial products. Extensive vegetated roofs may be established in various ways: through prefabricated vegetation mats, shot planting, seed sowing, and spontaneous self-established vegetation. Few references identify a third category of green roofs: simple-intensive (semi-intensive) [13] which are vegetated with lawns and ground covering plants. These roofs require frequent maintenance including cutting, watering, and fertilization. There is no agreement between different sources regarding the thickness of the soil for various roof types. A green roof with a substrate depth of 110-150 mm can be regarded by different authors as intensive or extensive. Therefore caution is needed while comparing green roofs performance towards obtaining benefits which depend on the soil layer thickness.

Establishing green roofs, or vegetated roofs, can improve stormwater management, conserve energy, mitigate urban heat island effects, increase longevity of roofing membranes, improve return on investment compared to traditional roofs, reduce noise and air pollution, increase urban biodiversity, and provide a more aesthetically pleasing environment[14-19]. Green roofs in urban areas are among several technologies for developing more environmentally sustainable buildings and creating visually attractive urban environments. Green roofs have been more common in central Europe and are now being constructed on buildings around the world [20-22].

2.2 Project Sites

The project sites are on two buildings (Building A and Building B) located in the Dujiangyan campus of Sichuan Agricultural University, Sichuan Province of China. The roof area of Building A is about 25m ×12m, and of Building B is about 76m×13.2m. The two buildings are about 125m apart from each other. Fig. 1 shows the map of project sites from GIS treatment and the virtual 3-D map by the Google Earth.

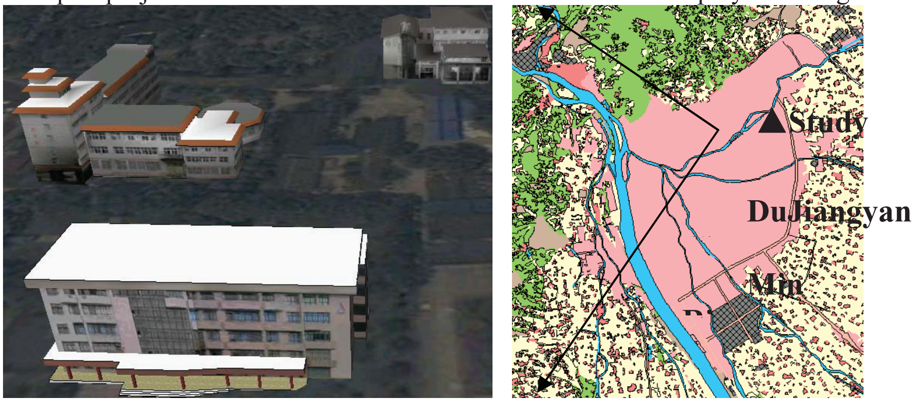

Fig.1 Map of proposed project sites (GIS treatment and 3-D Google Earth)

The roof of Building A is the “control” site, on which no green roof and no blue roof is installed. Therefore the data collected from Building A represent the quality and quantity of ordinary roof runoff. The roof of Building B is divided into three parts shown in Fig. 2.

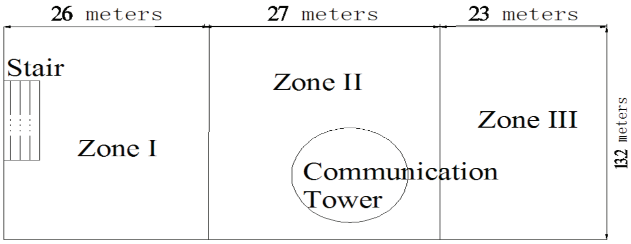

Fig.2 Setup of experimental site on the roof of Building B.

(**Zone I:** the traditional green roof, or “roof garden”, which is the traditional green roof installation in Chengdu; **Zone II:** the advanced green roof, which will be designed and built using current guidelines and technology available in international literature; **Zone III:** the “blue roof” designed only as a storm water storage/retention facility.)

2.3 Application System structure and function

The green roof with useful environment efficiency including stormwater management, energy conservation, urban heat island effects mitigation, noise and air pollution reduce, urban biodiversity increase, and more aesthetically pleasing environment, can be effectively designed by GIS and Google Earth. Fig. 3 presents the main system structure and function of Green Roofs assessment.

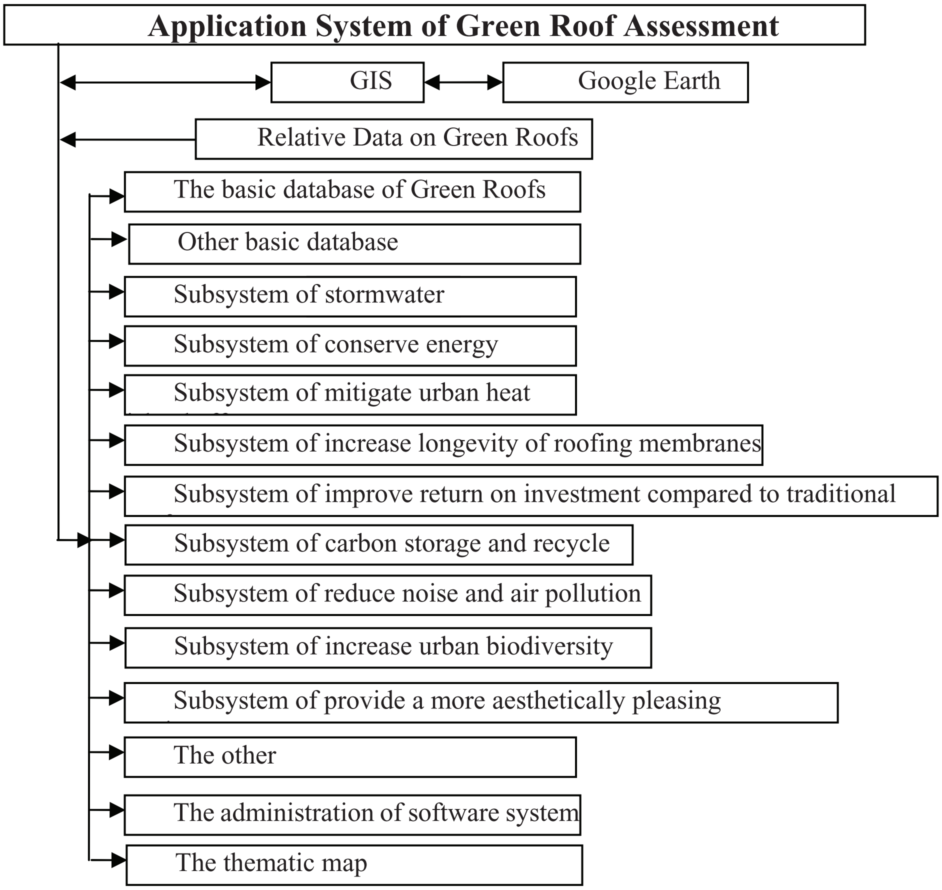

Fig. 3 System structure and

The main subsystem include the stormwater management, conserve energy, mitigate urban heat island, increase longevity of roofing membranes, improve return on investment compared to traditional roofs, Carbon storage and recycle, reduce noise and air pollution, increase urban biodiversity, provide a more aesthetically pleasing environment and the other.

2.4 System Design Methods

The d esign composes of five phases and the flow chart can be seen in Fig. 4.

The first phase: the investigation of system requirements. I n order to make the established system more perfect, applicable and scientific, the investigation is one of the main programs. By the investigation, the duty and administration scope from people in different distinction and confirm the sharing data from all investigation data can be found out.

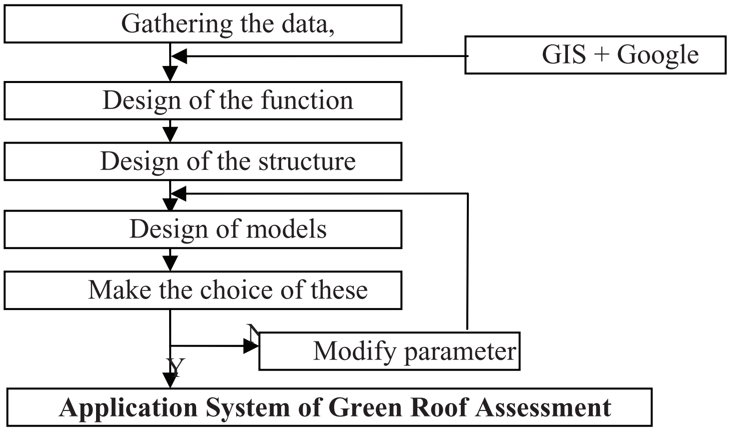

Fig.4 Flow chart of system

The second phase: to obtain the basic data, including the investigation and ingathering of the green roofs' environmental background data in studied urban area and other data.

The third phase: the research of models, including the model of different assessment methods.

The fourth phase: the design of system. (1) design system function; (2) design the collectivity of the system; (3) design the energy of system; (4) design the databases, such as the design of the different green roof information database and so on; (5) design the space databases and property databases; (6) design the module of system ; (7) adjust and perfect the design of syst em.

The fifth phase: to integrate the design of system in software platform.

2.5 System integration

Based on the technology of GIS and Google Earth, the system integration was unified and developed in the software development platform in Fig. 5.

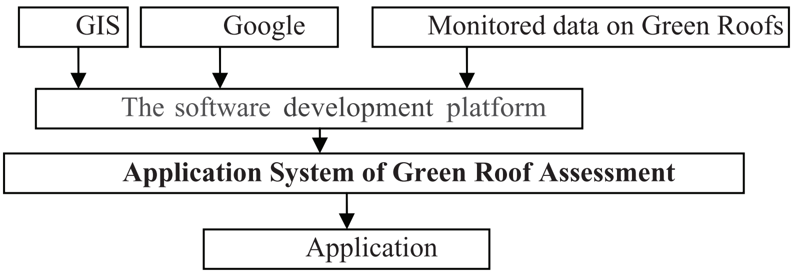

Fig.5 Method of system integration for green

3 Green Roofs Assessment

The green roof with useful environment efficiency including stormwater management, energy conservation, urban heat island effects mitigation, noise and air pollution reduce, urban biodiversity increase and more aesthetically pleasing environment, can be effectively assessed by designed application system.

This green roof module allows the energy modeler to explore green roof design options including growing media thermal properties and depth, and vegetation characteristics such as plant type, height and leaf area index. These tests focus on evaluating the role of growing media depth, irrigation, and vegetation density (leaf area index) on both natural gas and electricity consumption. Building energy consumption was found to vary significantly in response to variations in these parameters. Further, this response depended significantly on building location (climate).

Energy change was simulated and temperature contrast curves of measurement and simulation in 24 hours is shown in Fig. 6. It can be seen that simulated temperature had a good agreement with the measured value.

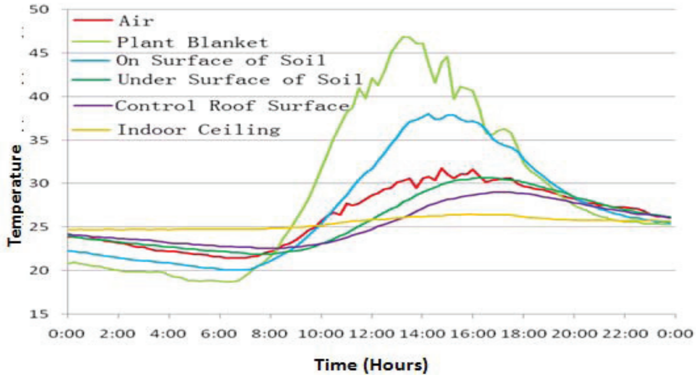

Fig. 6 Temperature curve between measured and calculated curves

As with a traditional roof, energy balance of a green roof is dominated by radioactive forcing from the sun. This solar radiation is balanced by sensible (convection) and latent (evaporative) heat flux from soil and plant surfaces combined with conduction of heat into the soil substrate and long-wave (thermal) radiation to and from the soil and leaf surfaces.

Based on other measured data verification, this appliction system of green roofs assessment can effectly express relavent iformation for green roofs.

4. Conclusions

By using the technology of GIS and Google Earth, an application system of green roofs assessment has been designed and conducted to estimate performance of green roofs in studied site. The great advantage of green roofs can be expressed by this application system. Expanding green roofs with monitored data on spacical construction, temperature and rainfall runoff has been dicussed by this application system. The energy saving efficiency and stormwater runoff play important role and effect from green roofs. Next research may add the construction design of new green roofs, so that the different and original information from new green roofs and existing green roofs can totally be gathered and easily show by 3S(GIS, RS and GPS) technology and google earth.

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References

[1] Kumar R, Kaushik S C. Performance evaluation of green roof and shading for thermal protection of buildings . Building and Environment 40 (11): 1505-1511.(2005)

[2] Federer, C. A. Effects of trees in modifying urban microclimate; SymposiumonTreesandForests in an Urbanizing Environment, Amherst, MA, Aug 18-21, University of Massachusetts, Cooperative Extension Service, (1970).

[3] Bertnatzky, A. The contribution of trees and green spaces to a town climate. Energy and Buildings 5(1982), 1-10.

[4] Simpson, J. R.; McPherson, E. G. Effects of Urban Trees on Regional Energy Use and Avoided Carbon; Preprints, 3rd urban environment symposium 2000; August 14-18, 2000, Davis, CA; American Meteorological Society: Washington, DC, (2000) ,pp143-144.

[5] Scholz-Barth, K. Green Roofs: Stormwater Management from the TopDown; Environmental Design&Construction Magazine homepage; http://www.edcmag.com/CDA/ ArticleInformation, (2003)

[6] Santamouris, M., Pavlou, C., Doukas, P., Mihalakakou, G., Synnefa, A., Hatzibiros, A., Patargias, P. Investigating and analysing the energy and environmental performance of an experimental green roof system installed in a nursery school building in Athens, Greece. Energy, 32(2007):1781–1788.

[7] Takebayashi, H., Moriyama, M. Surface heat budget on green roof and high reflection roof for mitigation of urban heat island. Build. Environ, 42(2007):2971–2979.

[8] Kosareo, L., Ries, R. Comparative environmental life cycle assessment of green roofs. Build. Environ, 42(2007), 2606–2613.

[9] Clark, C., Adriaens, P., Talbot, F. B. Green Roof Valuation: A Probabilistic Economic Analysis of Environmental Benefits. Environ. Sci. Technol. 42 (2008):2155–2161.

[10] Van Renterghem, T., Botteldooren, D. Numerical evaluation of sound propagating over green roofs[J]. J. Sound and Vibration, 317(2008):781–799.

[11] XU Rui, HUANG Xiao-xue, LUO Lin, LUO Hong-bing. Assessment of Green Roof by Google Earth.The 6th International Conference on Urban Watershed Management and Lake Eco-system Protection and Resource Utilization & The 1th International Conference on Sustainable Development of the Poyang Lake Region.125-128. (2009)

[12] Kingsbury, P., Jones III, J.-P. Walter Benjamin’s Dionysian adventures on Google Earth. Geoforum 40(2009), 502-513.

[13] FLL, Richtlinie für die Planung, Ausführung und Pflege von Dachbegrünungen (in German) (Guidelines for planning execution and upkeep of Green roof sites). Bonn, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau E.V. (2002)

[14] Kristinl. Getter, D. Bradleyrowe, G. Philiprobertson, Bertm. Cregg, Jeffreya. Resen. Carbon Sequestration Potential of Extensive Green Roofs. Environ. Sci. Technol. 43(2009), 7564–7570.

[15] Yang, J., Yu, Q., Gong, P. Quantifying air pollution removal by green roofs in Chicago. Atmos. Environ. 42(2008):7266–7273.

[16] Getter, K. L., Rowe, D. B. The role of extensive green roofs in sustainable development. Hort Science, 41 (5):1276–1285. (2008)

[17] Oberndorfer, E., Lundholm, J., Bass, B., Coffman, R. R., Doshi, H., Dunnett, N., Gaffin, S., KÖhler, M., Liu, K. K. Y., Rowe, D. B. Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. BioScience, 57(10):823–833. (2007)

[18] Justyna Czemiel Berndtsson. Green roof performance towards management of runoff water quantity and quality: A review. Ecological Engineering, 36(2010):351–360.

[19] Wong, N. Mentens H., Tan, P.Y., Chen, Y. Study of thermal performance of extensive rooftop greenery systems in the tropical climate. Build. Environ. 42(2007):25–54.

[20] Brenneisen, S. Space for urban wildlife: designing green roofs as habitats in Switzerland. Urban Habitats, 4 (1): 27–36. (2006)

[21] Bengtsson, L., Grahn, L., Olsson, J. Hydrological function of a thin extensive green roof in southern Sweden. Nordic Hydrol. 36(3): 259–268. (2005)

[22] Susana Saiz, Christopher Kennedy, Brad Bass, Kim Pressnail. Comparative Life Cycle Assessment of Standard and Green Roofs .Environ. Sci. Technol. 40(2006), 4312-4316.